NATURAL RESOURCE ABUNDANCE, RENEWABLE ENERGY, AND ECOLOGICAL FOOTPRINT LINKAGE IN MENA COUNTRIES

Abstract

Apart from being vulnerable to the menace created by climate change, the MENA countries consume more of non-renewable energy despite their resource endowments and great renewable energy potentials. Energy consumption, natural resource exploitation and urbanization may add to environmental degradation since ecological distortions emanate from human activities. This study investigates the effects of the aforementioned variables on the ecological footprint in MENA countries. The findings confirm the EKC hypothesis and further reveal the negative impact of natural resource and economic growth on the environment. Renewable energy and urbanization reduce the ecological footprint. The FMOLS and DOLS were applied to obtain the country-specific results. Further findings suggest a feedback causality between urbanization, economic growth and ecological footprint. Policy directions based on the findings are extensively discussed.

Keywords: Renewable Energy; Ecological Footprint; Natural Resources; Urbanization; MENA.

1. Introduction

The world currently faces many challenges. The core of these challenges relates to sustainable growth/development and environmental preservation. The later have gained lots of attention because the protection of the biodiversity is sacrosanct (Nathaniel and Iheonu 2019; Dogan et al. 2019). Human activities have been recognized as the major threat to environmental preservation, as it contributes to climate change and ecological distortions (Magazzino et al. 2020; Joshua and Bekun 2020; Ulucak and Khan, 2020). Questions relating to the existence of climate change is becoming less popular, rather, attention has been shifted to the effects of such ‘change’ on the environment. The continuous deterioration of the environment by human activities portrays danger for humanity, as it is just a matter of time until the evils associated with climate change become irreversible.

Developing countries, MENA inclusive, are vulnerable to climate change because they lack the capacity to efficiently cope with the problems emanating from it (Nkengfack and Fotio, 2019). Many developing economies have witnessed economic improvements in the current century. However, these improvements are not devoid of environmental pressure. For instance, humanity consumed more than 50% of the earth's biodiversity in 1961 and 44% more than was available in 2006 (Global Footprint Network, 2010). Therefore, to sustainably cater for the need of humanity, the regeneration capacity of 1.6 Earths is currently needed (Ahmed and Wang 2019; Lin et al. 2016).

The consumption of energy has immense impact on poverty reduction, sectoral development, and economic growth (Adedoyin et al., 2020b, 2020a; Kirikkaleli et al., 2020; Udi et al., 2020). Energy contributes to economic accomplishment and serves as a panacea for human needs. Apart from being consumed in different forms, it's (energy) consumption has continually been on the increase (BP, 2018). Economic growth and urbanization are the chief contributor to the unprecedented increase in energy consumption, especially non-renewable energy (NRE) (Ahmad et al. 2019; Wu et al. 2019). NRE are pollutants. They are finite and contributes to health hazards (Feron et al. 2019; Destek and Sarkodie 2019; Wang and Dong 2019; Ali et al. 2020). The desire to reduce GHGs have informed the call for renewable energy (RE) adoption (Destek and Sinha 2020; Sharif 2020; Ibrahiem 2020; Asongu 2020; Vélez-Henao 2020; Magazzino et al. 2020; Ahmed et al. 2020; Khan et al. 2020). RE is clean (Baloch et al. 2019; Nathaniel 2019) and low in emissions (Maji and Sulaiman 2019; Nguyen and Kakinaka 2019; Nathaniel and Bekun 2020).

As of 2009, MENA has about 60% of the global oil reserves which depleted to about 51% in 2016 (Zhang et al. 2017). The intense consumption of NRE in the region promotes environmental degradation through CO_2 emissions. In 2011, for instance, six MENA countries (Kuwait, Qatar, the UAE, Oman, Bahrain, and Saudi Arabia) were among the world's top twenty emitters (CDIAC, 2011). The over-reliance on crude oil made MENA countries to be vulnerable oil shock. This follows an increase hydrocarbons consumption, hence an increase in the EFP (World Bank, 2016). About 170million of the region's population resides in urban centres. The UN has projected that MENA's population will hit 430million in 2020, of which 280million will live in the urban areas. This shows a 65% increase in urbanization which could have a far-reaching impact on the regions ecological set up.

The MENA countries have gained significant economic progress in the past few decades. It is a heterogeneous region with similar challenges which include high unemployment rate, increase demand for energy, weak research capacity, and inadequate investment in RE (Saidi, et al. 2018). MENA has gained lots of attention because of its resource endowments, RE potentials, and vulnerability to climate change (Gorus & Aslan 2019; Waterbury, 2017). Despite it RE potentials, and abundant resource endowments, the region still suffers from environmental issues resulting from the continuous consumption of fossil fuels, a NRE source. Policymakers in this region aim to achieve environmental sustainability amidst sustainable development. Sustainable development, energy consumption and environmental quality are interconnected. Therefore, sustainable development requires the adoption of environment-friendly energy. This will require a transition from the consumption of fossil fuels to renewables which is a core tenet of the SDGs 9.

Economic growth has persisted in MENA countries. The GDP of MENA countries rose from US$4,973.38b to US$7,809.72b between 1990 and 2016, with 6.9% growth rate in

2016 (World Bank, 2018). This growth has informed an increase in energy demand in the region. Economic growth/expansion drives industrialization which in turn promotes natural resource extraction. An increase in the consumption of natural resources (NRR), through deforestation, mining, industrialization, and agriculture can deteriorate the environment (Danish et al. 2019a). The extraction and exploitation of NRR give rise to income increase while decreasing biocapacity and increasing the EFP (Panayotou, 1993).

Of recent, EFP has gained attention as an adequate measure for environmental quality (Solarin 2019; Danish et al. 2019b). Recent studies (like Danish and Wang 2019; Mikayilov et al. 2019; Ahmed et al. 2019; Destek & Sarkodie 2019; He et al. 2019; Zafar et al. 2019; Fakher 2019) have used the EFP for this purpose. If the inculcation of efficient environmental management practices into consumption and production activities declines NRR depletion, thereby allowing resources to regenerate. However, production activities in MENA countries are driven by NRE sources. The energy consumed in MENA is dominated by fossil fuels because of its abundance. On the flip side, renewable energy (REN) is sustainable and low in emissions. Though, urbanization can also create positive externalities, public service provision, and economies of scale. Urbanization can improve the income of people living in urban centres. This income increase will drive their demand for REN, resulting in EFP decrease (Danish & Wang, 2019)

The contributions of this study are hydra-headed. (i) The study is the first to explore the determinants of the EFP by incorporate natural resource rent, urbanization, and REN for MENA countries. (ii) Potential factors like REN and natural resource rent are included in the pre-determined model of EFP and income. These factors would provide insight and expose the contributions of NRR earning of the MENA region to their pollution drive and policy. The mitigation of climate change is the lead policy agenda in the MENA region. The need to provide a guideline to achieving mitigation targets makes this study which examined the drivers to attaining SDGs by 2030 in terms of reducing the EFP in MENA countries to be sacrosanct. (iii) We adopt estimation techniques (mainly second-generation) which are reliable and robust for cross-sectional dependence (CSD), endogeneity, heterogeneity, autocorrelation, and heteroscedasticity issues.

The current study is organized as follows: section 2 delivers the literature review. The methodology, model and data are presented in section 3. Section 4 discusses the results. Section 5 presents the conclusion along with policy directions.

2. Literature Review

Energy consumption may lead to environmental degradation, although increased consumption of REN, contributes to mitigating environmental deterioration while the consumption of energies that are NRE, contributes to CO_2 emissions (Dogan and Inglesi-Lotz, 2017). However, how abundant the NRR is may affect environmental sustainability and contribute to environmental degradation. This is because, during exploration and extraction of natural resources, emission of greenhouse gases may occur which may affect the environment. Also, Urbanization which leads to trade openness, tourism and inter-nation dependence may be good for economic development and growth. Cities go through a number of environmental challenges as they develop, this may be due to emission of greenhouse gases which contributes to environmental degradation. However, in order to reduce the adverse effect of urbanization, activities should be located closer to each other so as to ensure better access to services. Meanwhile, ecological modernization requires that there is environmental re-adaptation of the developments in the industrial developments and economic growth. This will mean economic development, industrial development and the growth of the economy.

2.1 Impact of Energy Consumption on the Ecological Footprint

Energy consumption has become an issue of necessity for the economic development of nations; however nonrenewable energies have been known to contribute immensely to environmental degradation of countries. Therefore, more relevance should be placed on REN sources in the energy mix so as to encourage and support the use of REN and clean technologies (Dogan and Inglesi-Lotz, 2017). This requires that when considering energy sources, REN sources such as wind, solar, biomass should be adopted in the energy mix of MENA countries, this will lead to the reduction in the emission of greenhouse gases that may deplete the environment. Furthermore, the pattern of energy consumption and the path economic development takes have begun to be in line with the environmental policies of countries (Ozcan et al., 2020).

There exists a two-way causality link between energy consumption and CO_2 emission, suggesting that the former may drive the later and CO_2 emission increases (Al-Mulali and Ozturk, 2015). This has made it necessary to ensure that energy consumption policies and economic development policies are made to promote the sustainability of the environment. The consumption of energy from, gross domestic product, the level of urbanization and Trade openness increase air pollution both in the short and long run (Al-Mulali et al., 2016). Technologies with little or no emissions of greenhouse gases will help maximize wood biomass consumption as a REN source (Maji and Sulaiman, 2019). Increased commitment towards achieving sustainable energy is required so as to ensure economic growth as well as environmental sustainability (Maji and Sulaiman, 2019). Also, REN can help enhance the environmental quality (Bélaïd and Youssef, 2017). Countries should focus more on energy consumption from REN and NRE sources for an increased level of income. It is important for countries like France, Canada, Japan, England and the US to invest in techniques that inculcate renewables (Tugcu et al., 2012). It should be noted that the result as to whether there exists a relationship between them differs by country, while some studies attach economic growth to energy consumption, other studies such as Tugcu et al., (2012) and Destek and Aslan (2017) concluded that neither REN nor NRE necessarily adds to economic growth.

2.2 Impact of Urbanization on Ecological Footprint

Urbanization is usually as a result of globalization. This is because as trade increases, tourism grows, industrialization sets in, and the more the population moves towards urbanization. However, environmental sustainability is usually threatened as urbanization grows this is because industrial activities increases and greenhouse gases such as carbon dioxide is released into the atmosphere. Urbanization can actually drive CO_2 emissions (Yu et al., 2017). Khan et al., (2019) variables like financial development, urbanization, energy consumption, and even globalization are determinants of CO_2 emissions in Pakistan, while innovation, FDI, and trade abate menace created by CO_2 emissions. Also, urbanization is a key factor driving energy consumption. Although its contribution to energy consumption may vary among income countries, (Wang et al., 2019).

Furthermore, in order to reduce climate change and its impact on the environment, the quality of the governance plays an important role in the economic and social readiness, (Sarkodie and Adams, 2018). However, in order to ensure that urbanization positively affects the environment and its effect on the economy is significant, REN should be adopted in industrial activities. Also, the direction of the causality between REN and economic growth depends on the market conditions of the countries (Wadström et al., 2019). Energy consumption, which is imperative for industrial activities, real income/output as well as the level of globalization plays a significant role in ensuring the sustainability of the environment (Akadiri et al., 2018).

2.3 Impact of Economic Growth on the Ecological Footprint

The aim of any nation will be to achieve environmentally sustainable economic growth, this is because economic development as much as economic growth is important, environmental sustainability is imperative. The environmental performance level is contributed to by economic growth and pattern of energy consumption (Ozcan et al., 2020). Economic growth promotes the sustainability of the environment when there is a shift away from the NRE consumption that may cause CO_2 emissions which may lead to environmental degradation. Electricity consumption causes economic growth (Adom, 2011). There exists a significant relationship between REN and NRE generation and economic growth (Atems & Hotaling, 2018). Promoting renewable energies contributes not only to the environment but also to the economy (Inglesi-Lotz, 2016; Ozcan et al. 2020). The consumption of NRE increases EFP (Destek and Sarkodie, 2019).

Many studies have looked at the the relationship that exists between energy consumption, urbanization and environmental sustainability, and how economic growth impacts on environmental sustainability (Dogan and Inglesi-Lotz, 2017; Ozcan et al., 2020). This study, however, looks at how natural resources abundance, RE and urbanization affect environmental sustainability in MENA countries. Maji and Sulaiman (2019) concluded that REN consumption delays the growth process in West African countries, this may be because the region and method adopted in the study differ. Also, according to Acheampong (2018), economic growth does not exacerbate energy consumption. For most countries, economic growth has no causal impact on carbon emissions. Carbon emission positively causes economic growth. This is however contrary to findings from other researches on the relationship.

3. Data and Methodology

3.1 Data

To explore the linkage between urbanization, REN, natural resources, economic growth, and EFP, we utilized annual data of 1990-2016 for 13 MENA countries. The time period for the study was informed by data availability. Data on EFP ends in 2016, while the data on REN starts from 1990. See Table 1 on the source and measurements of the variables.

Table 1: Data, Measurement, and Source

S/N	Indicator Name	Measurement	Source
1	Urbanization	percentage of total population	WDI (2019)
2	Natural Resource Rent	% of GDP	✓
3	GDP Per Capita	in constant 2010 USD	✓
4	Renewable Energy	% of total energy consumption	✓
5	Ecological Footprint	global hectares per capita	GFN (2019)

Note: GFN represents Global Footprint Network.
Sources: Author's compilation.

Our measure of environmental degradation (EFP) is made up of grazing land, forest land, ocean, carbon footprint, cropland, and built-up land). The EFP is also used to juxtapose between a nation's wealth and how much of it they have consumed (Bilgili et al., 2019). Environmental wellness, evaluation, sustainability, resources management could all be assessed through the EFP (Solarin et al., 2019). All these and other features make the EFP far more superior to CO_2 emissions.

3.2 Method

The econometric procedure of this study begins with the CSD test. The CSD test will serve as a guide for other procedures. Ignoring CSD will result in biased estimates and estimator inefficiency. The null hypothesis of the test is given as:

$$H_0: \rho_{ij} = corr(\mu_{it}, \mu_{jt}) = 0 \ \forall \ i \neq j \tag{1}$$

Where ρ_{ij} represents the pairwise correlation coefficient of the disturbance term. The existence of CSD may render the conventional unit root tests invalid and therefore misleading. The study focused on unit root tests that account for CSD. We used the Cross-sectional augmented IPS (CIPS) test of Pesaran (2007) to achieve this purpose. See Eq 2 for the test equation.

$$\Delta y_{it} = \varphi_i + \beta_i y_{i,t-1} + \tau_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + \varepsilon_{it} \tag{2}$$

The Prais-Winsten regression model with panel-corrected standard errors (PCSE), which is robust for CSD, was used to show the interactions among the variables. The PCSE was further preferred to the feasible generalized least squares (FGLS) method because the later yields incorrect standard errors, while the PCSE is robust amidst heteroskedastic and serial correlation. Since we used 27 annual observations for 13 MENA countries, we corrected for first-order autocorrelation, AR(1), within panels. We also controlled for time-specific and country-specific disturbances by estimating the model through a two-way fixed effect technique. The model takes the form:

$$Y_{it} = \varphi X_{it} + \mu_i + \varepsilon_t + e_{it} \tag{3}$$

Where Y_{it} is the dependent variable, while φX_{it} is the independent variable for each country which varies over time. μ_i and ε_t are the country-specific and time-specific disturbance terms respectively. The unique disturbance term is represented as e_{it}. For robustness, the FMOLS proposed by Pedroni (2000) and the DOLS suggested by Mark and Sul (2001) and Kao and Chiang (2000) were used. The DOLS is estimated using Eq 4. which is given as:

$$EFP_{it} = \mu_i + x_{i,t}\Psi_{i,t} + \sum_{j=-p}^{p} \beta_j EFP_{i.t-j} + \sum_{j=-q0}^{q0} p_{1.j} NRR_{i.t-j} + p_{2.j} \sum_{j=-q1}^{q1} GDP_{i.t-j} + p_{3.j} \sum_{j=-q2}^{q2} GDPsq_{i.t-j} + p_{4.j} \sum_{j=-q3}^{q3} URB_{i.t-j} + p_{5.j} \sum_{j=-q4}^{q4} REN_{i.t-j} + \varepsilon_{it} \tag{4}$$

p and q are the number of leads/lags. The long-run relationship is estimated from the FMOLS equation given as:

$$EFP = \mu_i + x_{i.t}\psi + v_{it} \tag{5}$$

$$x_{i.t} = x_{i.t} + \mathfrak{C}_{i.t}$$

Where x is 5*1 vector of explanatory variables, μ_i is the intercept while $\mathfrak{C}_{i.t}$ and v_{it} are the error terms. However, the estimation of ψ is expressed as:

$$\hat{\psi}_{FMOLS} = \left(\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{i.t} - \bar{x}_{i.t}) * (x_{i.t} - \bar{x}_{i.t})'\right)^{-1} * \left(\sum_{i=1}^{N} \left(\sum_{t=1}^{T}(x_{i.t} - \bar{x}_{i.t}) * \widehat{EFP}_{it} - T\hat{\Delta}_{v\mathfrak{C}}\right)\right) \quad (6)$$

4. Results and Discuss of Findings

The descriptive statistic and correlation results are reported in Table 2. NRR is the least volatile. REN is also less volatile than URB, and GDP, but EFP is less volatile than GDPsq. All variables except REN and NRR have a negative association with EFP, while NRR and URB are positively associated with GDP. This, however, does not suggest causation.

Table2: Descriptive Statistic and Correlation

	EFP	GDP	GDPsq	REN	NRR	URB
Mean	50526	12694	4.58E+0	9.6159	12.482	63.137
Median	30020	4181.4	17485	2.1671	5.9623	64.393
Maximum	2.62E+0	70298	4.94E+0	85.628	64.149	90.506
Minimum	41571	765.60	58614	0.0000	0.0000	20.931
Std. D	55203	17259	1.01E+0	19.081	14.788	19.214
Correlation						
EFP	1					
GDP	-0.1303	1				
GDPsq	-0.0907	0.9586	1			
REN	0.0034	-0.2710	-0.1844	1		
NRR	0.2819	0.0589	0.0248	-0.2259	1	
URB	-0.1875	0.3825	0.2497	-0.5004	-0.0758	1

Source: Author's Computation.

When dealing with a sample of countries that are spatially close, the data may be suffering from cross-dependence which if not dealt with may lead to wrong inferences. Therefore, to establish if this problem exists and to adequately control for it, the data is tested with a battery of techniques such as Breusch and Pagan (1980), and Pesaran (2004) tests. The outcomes shown in Table 3 indicate the tenacity of the problem. The significance of the test statistics across the three specifications confirms CSD. Therefore, techniques that control and corrects for CSD are deployed in subsequent analysis.

Table 3: Cross-sectional Dependence Test

Variables	*Breusch-Pagan LM*	*Pesaran scaled LM*	*Pesaran CD*
Ecological Footprint (log)	1501.454***	113.9675***	35.08649***
GDP (log)	1089.012***	80.94575***	20.03653***
GDP squared (log)	1088.494***	80.90426***	19.95165***
Urbanization (log)	1562.966***	118.8925***	33.1762***
Natural Resources (log)	550.5551***	37.83469***	13.11325***
Renewable Energy (log)	364.0479***	29.46656***	2.003187**

Note: *** and ** imply statistical significance at the 1% and 5% levels respectively.
Source: Authors' Computations

Having ascertained the presence of CSD, the Pesaran (2007) and augmented Dickey-Fuller panel unit root tests which control for CSD are used. The findings from these tests abbreviated as CIPS and CADF are shown in Table 4.

Table 4: Panel Unit Root Tests

Variables	*Level*		*First Difference*	
	CIPS	*CADF*	*CIPS*	*CADF*
Ecological Footprint (log)	0.98718	22.693	-9.84816***	141.783***
GDP (log)	1.77425	18.8763	-4.59348***	67.9005***
GDPsquared (log)	1.94947	18.2182	-4.5585***	67.155***
Urbanization (log)	0.08769	45.7235	-2.65272***	57.5896***
Natural Resources (log)	-0.24968	27.1463	-8.37345***	120.723***
Renewable Energy (log)	2.20956	14.8987	-7.10036***	93.7697***

Note: *** implies statistical significance at the 1% level; CIPS: Cross-sectional Im, Pesaran and Shin; CADF: Cross-sectional Augmented Dickey-Fuller
Source: Authors' Computations

With the outcome of the stationarity tests (I(1)), analysing long-run associations begin by establishing whether the variables move together in the long-run. This is validated from the results of the cointegration analyses using both Kao and Chiang (1999) and Pedroni (1999) techniques. The cointegration regression is performed on two different specifications: (1) with intercept and (2) without cross-sectional means. The outcomes shown in Table 5 confirm that the null hypotheses of no co-integration is rejected at different statistical significance levels ranging from 1% to 10%.

Table 5: Panel Cointegration Results

Cointegration Tests		*Intercept*	*No Cross-Sectional Means*
Kao (1999)	Modified Dickey-Fuller	1.3316*	-2.0473**
	Dickey-Fuller	0.853	-1.6257*
	Augmented Dickey-Fuller	2.7297***	0.523
	Unadjusted modified Dickey-Fuller	-0.9287	-3.146***
	Unadjusted Dickey-Fuller	-1.1221	-2.1133**
Pedroni (1999, 2004)	Modified Phillips-Perron	0.4002	1.1822
	Phillips-Perron	-4.7165***	-3.7415***
	Augmented Dickey-Fuller	-4.3826***	-3.7496***

Note: Tests performed using 2 lags. ***, ** and * represent significance at the 1%, 5% and 10% levels, respectively.

Source: Authors' Computations

In the event that there exist panel-level heteroskedasticity and correlation across the panels, estimations from the panel-correlated standard errors (PCSE) technique which also corrects for cross-sectional dependence and heteroskedasticity are performed based on three different expectations of the form of autocorrelation: (1) no autocorrelation, (2) common autocorrelation of *AR*(1) process, and (3) panel-specific autocorrelation of *AR*(1) process. The findings which are mostly consistent across the three specifications are shown in Table 6.

Table 6: Panel-Corrected Standard Errors Results

Variables	*No Autocorrelation*	*AR(1) Process*	*Panel AR(1) Process*
Constant	-0.0977	4.2617	9.8967***
	(-0.03)	(1.28)	(3.11)
GDP (log)	4.5426***	3.7461***	2.5621***
	(5.18)	(4.44)	(3.30)
GDP squared (log)	-0.2265***	-0.1920***	-0.1291***
	(-4.88)	(-4.29)	(-3.13)
Urbanization (log)	-1.1305***	-1.1011***	-1.1685***

	(-5.07)	(-3.99)	(-4.82)
Natural Resources (log)	0.1579***	0.0450***	0.0543***
	(10.39)	(3.01)	(3.94)
Renewable Energy (log)	-0.1521***	-0.0238	-0.0704**
	(4.31)	(-0.68)	(-2.13)
No. of Observations	281	281	281
R-Squared	0.365	0.984	0.991
Wald Statistic	215.33***	42.66***	88.05***

Note: ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; *t*-statistics are in parentheses.
Source: Authors' Computations

The EKC hypothesis is evident in the data given the positive (negative) and statistically significant coefficient of GDP (GDP squared). Both relationships are significant at the 1% level across the three specifications. The outcome suggests that at the initial stages of economic growth, environmental degradation increases but as the economy grows and per capita income improves such that people resort to using efficient alternative energy sources, the contribution to the EFP declines. In essence, environmental degradation slows. This outcome is supported by Danish et al. (2019a), Nathaniel (2020), Bekun et al. (2019), Wu et al. (2017), Katircioglu et al., (2018) and Ozturk et al., (2016). However, this contradicts the findings of some studies (like Sarkodie 2018; Destek et al., 2018). Contradicting findings on the EKC hypothesis across similar studies is not unconnected to different econometric techniques deployed and the study scope under survey.

Across the three specifications, the negative coefficients of urbanization show its positive impact on reducing the EFP. It indicates that a percentage change in urban expansion yields a more than a percentage decline in the EFP thereby contributing to a cleaner environment. This finding gives credence to the supposition that increases in the purchasing power of urban dwellers leads to more demand for clean and alternative energy which reduces environmental pollution (Charfeddine et al. 2018; Ozturk et al., 2016) but contradicts Nathaniel et al., (2019) who discovered that urbanization has the most devastating impact on the EFP.

Other studies that have reported the horrendous effects of urbanization on the EFP include: Nathaniel et al. (2020) for CIVETS, and Wang and Dong (2019) for 14 SSA.

The coefficient of NRR is significant across the three specifications. It supports the argument that increasing NRR depletion worsens the environment. Studies like Hassan et al., (2019), Danish et al. (2019c) and Panayotou (1993) noted that increasing the extraction of NRR expedites the EFP. This is because economic growth spurs the need for natural resource extraction which contributes to environmental degradation (Danish et al., 2019a). MENA countries most rely on their natural endowment. The region has more than sixty per cent of the world's oil reserves (USDOE 2011). The exploitation of natural resources drives environmental degradation and reduces biodiversity. For instance, Bahrain, Saudi Arabia, UAE, Oman, Kuwait, and Qatar were among the world's top 20 emitters in 2011 (CDIAC, 2011).

Our findings on the impact of RE is somewhat inconsistent. The ngative and statistically significant coefficient when no autocorrelation is assumed indicates that RE abates environmental degradation. Similar findings to (Danish et al. 2019c; Bello et al., 2018; Alola et al., 2019; Destek et al., 2018; Wang and Dong, 2019) on the contributory impact of REN to the environment is obtained when panel-specific autocorrelation is assumed and the coefficient is negative. To test the robustness of our results, the dynamic and fully modified ordinary least squares techniques which control for possible autocorrelation and endogeneity of the variables are used. The findings shown in Table 7 are very similar and consistent with those of Table 6. For instance, both findings on the EKC hypothesis and natural resource are sustained and previous interpretations hold. Contrarily, the impact of urbanization on the EFP is reversed. The plausible argument for the aggravating impact of urbanization is that urban surge increases fossil fuel consumption thereby increasing the EFP (Danish and Wang 2019; Wang et al. 2016). In essence, the overall impact of urbanization on the EFP is uncertain in MENA.

Table 7: Robustness DOLS and FMOLS Results

Variables	*DOLS*	*FMOLS*
GDP (log)	5.073*** (6.281)	1.544** (2.438)
GDP squared (log)	-0.264*** (-6.257)	-0.081** (-2.369)
Urbanization (log)	2.246*** (3.556)	2.759*** (9.292)
Natural Resources (log)	0.085*** (3.409)	0.008 (0.481)
Renewable Energy (log)	0.057 (0.623)	0.011 (0.163)

Notes: ***, ** and * represent statistical significance at the 1%, 5% and 10% levels, respectively; fixed leads and lags (1,1) for DOLS analysis.
Source: Authors' Computations

We finalize our analysis by testing for causal relationships between/among the variables using the Dumitrescu-Hurlin (2012) non-Granger causality approach. As indicated in Table 8, there exist bi-causal relationships between GDP/EFP, URB/EFP, URB/GDP and NRR/GDP while uni-causal relationships exist between NRR/EFP, and NRR/URB. The outcomes of these causal analyses give support to the choice of variables used in this study.

Table 8: Dumitrescu & Hurlin Causality Results

Null Hypothesis:	*W-Stat.*	*Zbar-Stat.*	*Prob.*	*Conclusion*
GDP ≠> EFP	3.66863	2.09903	0.0358	Bidirectional causality
EFP ≠> GDP	6.79775	6.64003	3.00E-11	
URB ≠> EFP	4.63851	3.50654	0.0005	Bidirectional causality
EFP ≠> URB	9.28165	10.2447	0.0000	
NRR ≠> EFP	2.21035	-0.01723	0.9863	Unidirectional causality
EFP ≠> NRR	4.58583	3.43008	0.0006	
URB ≠> GDP	5.14445	4.24075	2.00E-05	Bidirectional causality
GDP ≠> URB	8.10143	8.53195	0.0000	
NRR ≠> GDP	3.65749	2.08286	0.0373	Bidirectional causality
GDP ≠> NRR	4.3347	3.06564	0.0022	
NRR ≠> URB	2.43982	0.31578	0.7522	Unidirectional causality
URB ≠> NRR	5.68574	5.02628	5.00E-07	

Note: GDP = gross domestic product; EFP = ecological footprint; URB = urbanization; NRR = natural resources. Renewable energy is excluded due to missing data in some of the cross-sections.
Source: Authors' Computations

Table 9: Country-Specific FMOLS and DOLS Results

FMOLS

	Algeria	Bahrain	Egypt	Iran	Israel	Jordan	Lebanon	Morocco	Oman	Sudan	Tunisia	UAE	Yemen
	lefp	lefp	Lefp	lefp	Lefp	lefp	lefp	lefp	lefp	lefp	lefp	lefp	lefp
lngdp	-40.29 ^{a}	1219.9 ^{a}	-2.457	88.10 ^{a}	5.170 ^{b}	44.98^{c}	-7.528^{c}	10.46 ^{a}	-108.9	39.71 ^{a}	4.872^{c}	56.81^{a}	17.34
	(-4.63)	(176.58)	(-1.24)	(8.15)	(3.08)	(1.97)	(-2.02)	(4.01)	(-0.63)	(3.94)	(2.08)	(6.02)	(1.80)
lgdp2	2.522 ^{a}	-61.19 ^{a}	0.225	-5.028 ^{a}	-0.248 ^{b}	-2.746	0.439^{c}	-0.580 ^{a}	5.661	-2.855 ^{a}	-0.215	-2.679 ^{a}	-1.198
	(4.77)	(-176.10)	(1.72)	(-8.12)	(-3.23)	(-1.94)	(2.07)	(-3.48)	(0.64)	(-4.15)	(-1.51)	(-6.07)	(-1.74)
lren	-0.062^{a}		-0.360 ^{a}	0.009	-0.143 ^{a}	-0.163	-0.233 ^{a}	-0.075		-1.080	-0.302 ^{b}	-0.284 ^{a}	-0.209
	(-4.10)		(-3.45)	(1.02)	(-3.58)	(-0.86)	(-10.95)	(-1.45)		(-1.73)	(-2.97)	(-6.35)	(-1.84)
lurb	1.236 ^{a}	84.51 ^{a}	-9.853 ^{a}	1.511 ^{a}	10.24 ^{a}	4.184 ^{a}	10.43 ^{a}	-1.188 ^{b}	9.988 ^{a}	4.201^{c}	-2.717 ^{a}	6.466 ^{a}	1.606 ^{a}
	(8.15)	(10.97)	(-6.52)	(13.15)	(7.16)	(5.28)	(12.64)	(-2.81)	(10.53)	(2.47)	(-3.44)	(7.59)	(10.68)
lnrr	-0.043	0.237 ^{b}	0.047 ^{a}	-0.027	-0.005	-0.030	0.045 ^{a}	-0.018	0.550 ^{b}	-0.002	-0.041 ^{b}	0.105 ^{b}	-0.054
	(-1.80)	(2.93)	(3.48)	(-1.60)	(-1.17)	(-1.48)	(4.58)	(-1.52)	(2.73)	(-0.11)	(-2.63)	(3.03)	(-1.54)
Const.	173.5 ^{a}	-6442.7	61.91 ^{a}	-372.9 ^{a}	-51.35 ^{a}	-186.2^{c}	2.906	-23.59^{c}	494.8	-129.9 ^{a}	3.571	-312.5 ^{a}	-51.16
	(4.84)	(6.34)	(5.60)	(-7.91)	(-8.56)	(-2.08)	(0.18)	(-2.40)	(0.59)	(-3.49)	(0.41)	(-6.54)	(-1.53)

t statistics in parentheses; ="^{c}p<0.05, ^{b} p<0.01, ^{a} p<0.001"

DOLS

	Algeria	Bahrain	Egypt	Iran	Israel	Jordan	Lebanon	Morocco	Oman	Sudan	Tunisia	UAE	Yemen
	lefp	lefp	Lefp	lefp	lefp	lefp	lefp	Lefp	lefp	lefp	lefp	lefp	lefp
lgdp	-52.89^{b}	399.5	-2.208	69.39 ^{a}	5.319	36.26	-1.301	12.70^{c}	-145.8	36.71	5.105	53.55 ^{a}	13.28
	(-2.66)	(1.56)	(-0.49)	(3.69)	(0.95)	(1.42)	(-0.70)	(2.05)	(-0.87)	(1.62)	(0.64)	(3.76)	(1.27)
lgdp2	3.279^{b}	-20.05	0.210	-3.958 ^{a}	-0.256	-2.203	0.085	-0.734	7.535	-2.647	-0.214	-2.526 ^{a}	-0.908
	(2.70)	(-1.56)	(0.71)	(-3.67)	(-1.00)	(-1.39)	(0.79)	(-1.87)	(0.88)	(-1.72)	(-0.44)	(-3.79)	(-1.22)
lren	-0.029		-0.336	0.016	-0.155	-0.301	-0.222 ^{a}	-0.087		-1.098	-0.335	-0.261^{a}	-0.189
	(-0.91)		(-1.43)	(0.51)	(-1.19)	(-1.47)	(-7.74)	(-0.68)		(-0.74)	(-0.98)	(-4.61)	(-1.61)
lurb	1.632 ^{a}	85.48 ^{a}	-9.382^{b}	1.477 ^{a}	10.86^{c}	4.284 ^{a}	9.958 ^{a}	-0.588	10.79 ^{a}	2.933	-4.118	6.751^{a}	1.577^{a}

	(5.10)	(3.94)	(-2.92)	(3.73)	(2.38)	(5.15)	(9.16)	(-0.63)	(10.37)	(0.88)	(-1.70)	(4.95)	(9.56)
lnrr	-0.068	0.351	0.045	-0.044	-0.007	-0.026	0.046^{a}	-0.020	0.465^{c}	0.008	-0.046	0.106	-0.040
	(-1.18)	(1.57)	(1.51)	(-0.84)	(-0.49)	(-1.16)	(3.38)	(-0.71)	(2.28)	(0.18)	(-0.88)	(1.89)	(-1.05)
_cons	224.4^{b}	-2357.8	59.07^{c}	-290.9^{a}	-54.57^{b}	-151.4	-22.42^{c}	-34.03	673.6	-114.6	7.557	-296.4^{a}	-36.90
	(2.72)	(-1.90)	(2.39)	(-3.62)	(-2.79)	(-1.51)	(-2.03)	(-1.49)	(0.83)	(-1.42)	(0.26)	(-4.12)	(-1.02)
t statistics in parentheses; ="^{c}p<0.05, ^{b}p<0.01, ^{a}p<0.001"													

Note: The output for REN are missing for Bahrain and Oman in both the FMOLS and DOLS estimations due to missing figures.
Source: Authors' Computations

The results from Table 9 (FMOLS) confirms the EKC hypothesis for Bahrain, Iran, Israel, Jordan, Morocco, Sudan, Tunisia, Yemen, and the UAE. RE mitigates environmental deterioration in all the countries except in Iran. However, the abating role of RE appears not to be significant in most of the countries. Urbanization surge promotes environmental degradation in all the countries except in Algeria, Bahrain, Tunisia, and Morocco were it is not particularly harmful. NRR adds to the EFP in the UAE, Oman, and Lebanon. The UAE is one of the highest exporters of crude oil in the world. Our result strongly suggest that the exploitation of NRR is the UAE is at the cost the environment. Studies like (Shihab 2001; El Gawad et al. 2008; Al-Qaydi 2006; Rawazik and Carroll 2009) have all confirmed the devastating influence of NRR on the environment in the UAE, while Soto and Haouas (2012) believed that the UAE must have outlived the NRR curse by making the benefits from NRR exploitation supersede its negative impacts. Lebanon is rich in natural gas, salt, gypsum, limestone, oil, iron ore, etc. Though, most of these resources are for local consumption, its exploitations have done no good to the environment. Earthquakes, sandstorms, deforestation, and dust storms in Lebanon have been attributed to the incessant exploitation of the countries NRR. Some of these results are further confirmed in the DOLS estimation.

5. Conclusion and Policy Direction

The study examined the effects of natural resource, renewable energy, and urbanization on the EFP in MENA countries from 1990 to 2016 within the EKC framework. With the evidence of CSD, we applied econometrics techniques that suit the characteristics of the dataset, and also yield robust estimates. A bidirectional causality was discovered between GDP and EFP, URB and EFP, URB and GDP, and GDP and natural resources, while a one-way causality flows from URB to natural resources and from NRR to EFP. Further findings from the results confirmed the EKC hypothesis for MENA. Economic growth and NRR drive environmental degradation by increasing EFP, while the overall impact of REN consumption and urbanization on environmental quality is uncertain.

The findings suggest the need for MENA countries to improve basic amenities, household income, infrastructural facilities etc. since increase in urbanization mainly emanates from discrepancies in development factors. Economic growth in MENA have encouraged the movement of economic activities to the urban centres resulting in rural-urban drift. An improvement in basic facilities that will improve the quality of life in the rural areas will help mitigate the upsurge in urbanization. The creation of smart cities will be a good step in the right direction. Smart cities encourage the efficient performance and quality of urban services including transportation, energy, etc. to attain environmental sustainability, innovation and efficiency.

Also, since the consumption of NRE is detrimental to the environment, policymakers need to adjust their energy portfolio and intensify the consumption of REN sources like hydropower, wind, tide, solar, etc. REN are clean, unlike fossil fuels (the major energy source in MENA) that degrades the environment. An aggressive investment in these energy sources will enhance environmental quality, ensure the safety of life, promote economic growth, and expedite the achievement of the SDGs by 2030. The transition from NRE to REN sources have not been smooth in MENA countries due to low income, low level of environmental awareness, and high cost of renewables. The provision of subsidized loans, tax rebates and holiday and low interest rate could act as a temporal palliative to the household. The government can also provide incentives to encourage industries to embark on clean production while heavily taxing the dirtier ones.

The horrendous effect of NRR of the EFP demands government’s effort to enact policies that will facilitate the sustainable use of their NRR which is accompanied by growing income, since economic growth drives resource exploitation. Data availability prompted the omission of some of the EFP determinants in this study, hence the limitation of the study. The study used the DOLS and FMOLS techniques which have some limited restrictions. However, a techniques with a non-linear structure may yield different results. Future studies may need to utilize a more comprehensive environmental indicator, extended dataset with newly developed estimation techniques.

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